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Air bag coating composition and bag.

An air bag coating composition is provided in the form of an aqueous silicone emulsion composition comprising (A) an aqueous emulsion of a hydroxyl-containing organopolysiloxane, (B) a reaction product of an amino-functional silane or a hydrolyzate thereof with an acid anhydride, an epoxy-functional silane or a hydrolyzate thereof, or an organosilane having an isocyanate radical and a hydrolyzable radical in a molecule or a hydrolyzate thereof, (C) colloidal silica, and (D) a curing catalyst. The composition is applied and cured to an air bag base fabric to form a tack-free, crack resistant coating thereon.

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FIELD OF THE INVENTION

This invention relates to an air bag coating composition and more particularly, to a coating composition suitable for forming coatings on plain weave fabrics of polyimide and polyester fibers for air bags. It also relates to an air bag having a coating of the composition cured to base fabric.

BACKGROUND OF THE INVENTION

The mainstream air bags were those bags made of nylon fabric coated with chloroprene rubber. As a substitute for the chloroprene rubber, air bags coated with silicone were recently developed for the purposes of improving heat resistance, weather resistance and flame retardance.

Air bag coating compositions based on chloroprene or silicone are generally prepared by adding curing agents, flame retardants, adhesion aids, reinforcements and the like to chloroprene rubber or silicone rubber, followed by diluting with organic solvents. The compositions are then applied to base fabrics of nylon or the like.

The air bag is of the design that it is normally folded to small dimensions, but instantaneously inflated when explosive gas is injected. On inflation, the coating applied to the air bag fabric is also instantaneously stretched following the air bag fabric. Thus the coating itself should be mechanically strong. Therefore, the currently available chloroprene and silicone air bag coating compositions both use base polymers of a relatively high molecular weight so that cured coatings thereof may have strength and elongation. The air bag coating compositions using high molecular weight base polymers, however, are quite difficult to apply to a coating thickness of 40 to 100 μm normally required for air bags using knife coaters, offset roll coaters, gravure coaters or the like. The air bag coating compositions using high polymers must be diluted with organic solvents to a sufficient viscosity to allow easy coating.

However, the use of organic solvents has serious problems that they have the risk of ignition by static electricity especially in the working environment and that they are harmful to the operator by way of inhalation or skin contact. In addition, evaporated solvents impose the problems that their recovery is very expensive and if not recovered, they cause air pollution. For these reasons, coating compositions free of organic solvents are now desired in all industrial fields.

Among means for changing the air bag coating composition to a solventless system, the simplest way is to reduce the viscosity of the base polymer to a sufficient level to allow for coating by means of a knife coater or the like. However, a base polymer having a lower degree of polymerization is somewhat low in mechanical strength so that cracks can form on the coating surface upon air bag inflation and hot explosive gas can bleed out therethrough. If the viscosity is reduced too low, the composition will strike through a base fabric or plain weave fabric of nylon fibers, resulting in a less smooth surface. If the composition on the rear surface is cured as struck-through and then wound up, the coated fabric gives rise to blocking. Additionally, the struck-through composition will adhere to rolls of the coating machine, adversely affecting operating efficiency and outer appearance.

It was thus proposed to use aqueous silicone emulsion compositions which cure into silicone elastomers as the solventless air bag coating composition. Prior art aqueous silicone emulsion compositions did not firmly bond to air bag base fabrics or plain weave fabrics of polyimide or polyester fibers.

Japanese Patent Application Kokai (JP-A) No. 16553/1981 discloses a silicone emulsion composition comprising an anionically stabilized hydroxylated diorganopolysiloxane, colloidal silica, and an organic tin compound or organic amine compound at pH 9 to 11.5. Undesirably, this composition is limited in many aspects upon application because of its poor bond to certain base fabrics and strong alkalinity.

A variety of proposals were made in order to improve the adhesion of compositions of this type. For example, JP-A 131661/1979 discloses an organopolysiloxane latex composition obtained by emulsion polymerizing a cyclic organosiloxane and a functional group-containing organotrialkoxysilane (e.g., aminoalkyltrialkoxysilane) in the presence of a sulfonic acid or quaternary ammonium salt surfactant. USP No. 3,817,894 discloses a silicone latex composition comprising a siloxane block copolymer including dimethylsiloxane and monophenylsiloxane units, water, a cationic surfactant, a nonionic surfactant, a filler and an amino-functional alkoxysilane. These compositions, however, are less stable due to the presence of cationic surfactants.

In general, silicone latexes are often prepared using anionic emulsifiers rather than cationic emulsifiers from the standpoint of stability of silicone latexes (see Japanese Patent Publication No. 18800/1968, for example). These systems have the serious drawback that if silicone latexes stabilized with anionic emulsifiers are combined with amino-functional silanes or partial hydrolyzates thereof for improving adhesion, then substantial thickening (viscosity increase) or gelation (formation of insoluble matter and

precipitates), occurs.

SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to provide an air bag coating composition which is free of an organic solvent, applicable to plain weave air bag fabrics without strike-through, easy and safe to work with, and which cures to coatings having excellent rubbery properties, good adhesion to air bag fabrics, and a tack-free surface. Another object of the invention is to provide an air bag having a cured coating of the coating composition formed thereon.

We have found that when an aqueous silicone emulsion composition comprising an aqueous silicone emulsion in which an organopolysiloxane having at least two hydroxyl radicals attached to silicon atoms in a molecule is emulsified in water, colloidal silica, and a curing catalyst is blended with a reaction product of an amino-functional silane or a hydrolyzate thereof with an acid anhydride, an epoxy-functional silane or a hydrolyzate thereof, or an organosilane having an isocyanate radical and a hydrolyzable radical in a molecule or a hydrolyzate thereof, or a mixture thereof, there is obtained a composition which is applicable to plain weave air bag fabrics of polyamide, polyester or the like without strike-through and firmly bondable to the fabrics. The composition cures to coatings having a tack-free surface, excellent rubbery properties, and high mechanical strength to prevent cracking upon inflation of the air bag. Additionally, the composition is safe due to the absence of an organic solvent, curable at room temperature simply by removing water, and easy to work with.

Accordingly, the present invention provides an aqueous silicone emulsion composition for forming a coating on an air bag, comprising

(A) an aqueous silicone emulsion in which an organopolysiloxane having at least two hydroxyl radicals attached to silicon atoms in a molecule is emulsified in water,

(B) at least one member selected from the group consisting of (b-1) a reaction product of an amino-functional silane or a hydrolyzate thereof with an acid anhydride, (B-2) an epoxy-functional silane or a hydrolyzate thereof, and (B-3) an organosilane having an isocyanate radical and a hydrolyzable radical in a molecule or a hydrolyzate thereof,

(C) colloidal silica, and

(D) a curing catalyst.

DETAILED DESCRIPTION OF THE INVENTION

Component (A) of the air bag coating composition of the invention is an aqueous silicone emulsion in which an organopolysiloxane is emulsified in water. The organopolysiloxane should have at least two hydroxyl radicals attached to silicon atoms in a molecule. Prior art well-known ones may be used since latitude is given as to the attachment site of hydroxyl radicals, the type of an organic radical attached to a silicon atom other than the hydroxyl radicals, molecular structure, degree of polymerization, and the like. The organopolysiloxane of the following average compositional formula is preferably used.



wherein R is a substituted or unsubstituted monovalent hydrocarbon group having 1 to 10 carbon atoms, more preferably 1 to 8 carbon atoms and letter a is a positive number of 1.70 to 2.05. R groups may be identical or different and selected from substituted or unsubstituted monovalent hydrocarbon groups, for example, alkyl groups such as methyl, ethyl, propyl, butyl and hexyl group; cycloalkyl groups such as cyclohexyl; alkenyl groups such as vinyl and allyl groups; aryl groups such as phenyl and tolyl groups; and substituted ones of these groups in which one or more of the hydrogen atoms attached to carbon atoms are replaced by halogen atoms, cyano groups or the like, such as chloromethyl, trifluoropropyl and cyanoethyl groups. Letter a is a positive number of 1.98 to 2.01. The preferred R groups are methyl, ethyl, phenyl, trifluoropropyl, cyanoethyl, vinyl and allyl groups. More preferably methyl group is present in an amount of at least 50 mol%, especially at least 80 mol%. The terminal groups of the organopolysiloxane should preferably be hydroxyl radicals. Desirably, the organopolysiloxane has a molecular weight of at least 10,000, preferably 10,000 to 500,000, more preferably 200,000 to 500,000 because coatings of lower molecular weight siloxanes become short of strength and elongation so that the coatings might crack upon inflation of the air bag. The polymerization degree may preferably be in the range of 3000 to 7000.

The organopolysiloxane may be prepared, for example, through ring-opening reaction of a cyclic siloxane such as an octaorganocyclotetrasiloxane, hydrolysis of a linear or branched organopolysiloxane

having a hydrolyzable radical such as alkoxy and acyloxy radicals, and hydrolysis of one or more organohalogenosilanes.

In preparing component (A), there may be used an anionic emulsifier which may be selected from conventional well-known ones. Preferred anionic emulsifiers are those which can be emulsion polymerization catalysts and exhibit surface activity, for example, sulfonic acids, sulfuric acids, phosphoric acids and salts thereof. Illustrative examples include aliphatic sulfates such as sodium lauryl sulfate, aliphatic hydrocarbon radical-substituted benzenesulfonates such as dodecylbenzenesulfonates, aliphatic hydrocarbon radical-substituted naphthalenesulfonates, polyethylene glycol sulfate salts, and lauryl phosphate salts.

Component (A) or aqueous silicone emulsion may be prepared by any of prior art well-known methods, for example, by emulsifying an organopolysiloxane having at least two Si-OH bonds in a molecule in water in the presence of an anionic emulsifier. Alternatively, the emulsion may be prepared by first emulsifying a cyclic siloxane such as an octaorganocyclotetrasiloxane in water in the presence of an anionic emulsifier, adding a well-known ring-opening polymerization catalyst thereto, and effecting polymerization at elevated temperatures, thereby synthesizing an organopolysiloxane having at least two Si-OH bonds in a molecule and at the same time, yielding an end aqueous emulsion. In the latter case, a trifunctional silane represented by $\text{R}^1\text{Si}(\text{OR}^2)_3$ wherein R^1 is typically an alkyl, alkenyl or aryl radical and R^2 is typically an alkyl or acyl radical may be added to the cyclic organopolysiloxane prior to emulsification, or such a trifunctional silane may be separately emulsified and then added to the cyclic siloxane emulsion.

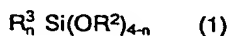
The amount of the anionic emulsifier used in the preparation of component (A) is preferably about 0.3 to 20 parts by weight, more preferably 0.5 to 5 parts by weight per 100 parts by weight of the organopolysiloxane. Less than 0.3 parts by weight of the emulsifier on this basis would little help emulsify the siloxane, failing to provide an end aqueous emulsion. More than 20 parts by weight of the emulsifier would eventually result in an elastomer having poor rubbery properties including strength, elongation and hardness.

The amount of water used is not critical as long as an aqueous emulsion is obtained. Generally, about 25 to 600 parts by weight of water is used per 100 parts by weight of the organopolysiloxane.

In preparing the aqueous emulsion, nonionic emulsifiers such as polyoxyethylene alkyl ethers and polyoxyethylene alkyl phenyl ethers or fluoride emulsifiers may be used together as long as they do not detract from rubbery properties.

Component (B) is critical component which is effective, when a coating composition is applied and cured to an air bag fabric, for improving the adhesion of the cured coating to the fabric. Component (B) is one or more members selected from the group consisting of (B-1) a reaction product of an amino-functional silane or a hydrolyzate thereof with an acid anhydride, (B-2) an epoxy-functional silane or a hydrolyzate thereof, and (B-3) an organosilane having an isocyanate radical and a hydrolyzable radical in a molecule or a hydrolyzate thereof.

(B-1) is a reaction product of an amino-functional silane or a hydrolyzate thereof with an acid anhydride. The amino-functional silane which can be used in the synthesis of the reaction product is preferably of the following formula:



wherein R^2 is an alkyl or acyl radical having 1 to 10 carbon atoms, R^3 is a 2-aminoethyl, 3-aminopropyl or N-(2-aminoethyl)-3-amino-propyl radical, and n is an integer of 1 to 3. Illustrative examples of the amino-functional silane include 3-aminopropyltriethoxysilane, N-(2-aminoethyl)-3-aminopropylmethyldimethoxysilane, 3-aminopropylmethyldiethoxysilane, N-(2-aminoethyl)-3-aminopropyltrimethoxysilane, N-triethylenediaminepropyltrimethoxysilane, N-triethylenediaminepropylmethyldimethoxysilane, etc. Also useful are (partial) hydrolyzates of these amino-functional silanes.

Examples of the acid anhydride include methyltetrahydrophthalic anhydride, methylhymic anhydride, benzophenonetetracarboxylic anhydride, phthalic anhydride, ethylene glycol bistrimellitate, maleic anhydride, pyromellitic anhydride, succinic anhydride, polyazelaic polyanhydride, trimellitic anhydride, nadic anhydride, phenylmaleic anhydride, methylhexahydrophthalic anhydride, hexahydrophthalic anhydride, dodecylsuccinic anhydride, dichloromaleic anhydride, and chlorendic anhydride, etc.

Reaction between the amino-functional silane and the acid anhydride may be carried out simply by mixing them at room temperature whereupon exothermic reaction readily takes place between them to provide an end product. It is to be noted that since the reaction product tends to gel, the reaction is desirably carried out in the presence of an organic solvent or solvents such as methanol, ethanol, butanol, isopropanol, acetone, methyl ethyl ketone, tetrahydrofuran, and dimethylformamide. Upon reaction, the amino-functional silane or its hydrolyzate and the acid anhydride may be used in equimolar amounts although either of them may be used in excess, if desired.

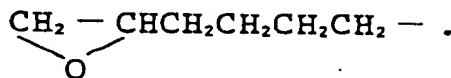
(B-2) is an epoxy-functional silane or a (partial) hydrolyzate thereof. The preferred epoxy-functional silane is of the following formula:



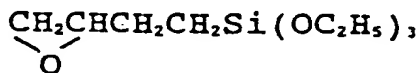
wherein R^2 and n are as defined above, and R^4 is a monovalent epoxy-containing organic radical such as



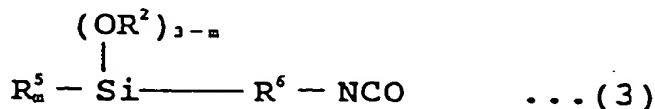
and



Illustrative examples of the epoxy-functional silane are given below.



(B-3) is an organosilane having an isocyanate radical and a hydrolyzable radical in a molecule or a (partial) hydrolyzate thereof. The preferred organosilane is of the following formula:



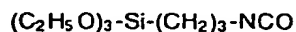
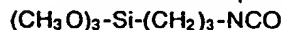
wherein R^2 is as defined above,

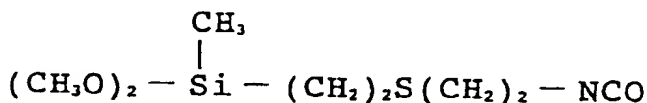
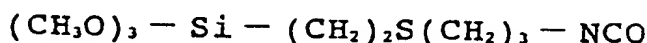
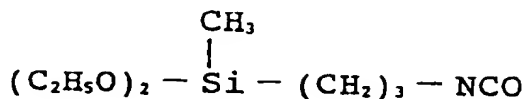
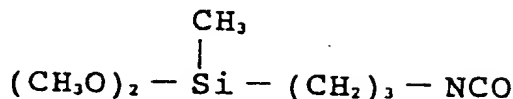
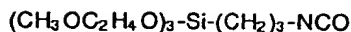
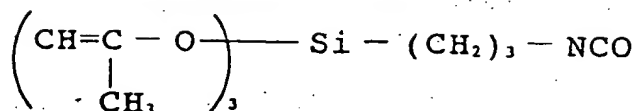
R^5 is a monovalent organic radical having 1 to 10 carbon atoms, for example, alkyl, alkenyl, aryl, aralkyl, and alkoxy-substituted alkyl radicals,

R^6 is a divalent hydrocarbon radical having 1 to 10 carbon atoms, for example, alkylene radicals such as methylene, ethylene and propylene, and arylene radicals such as phenylene, or a sulfur-substituted divalent hydrocarbon radical, and

n is a number of from 0 to 3.

Illustrative examples of the organosilane are given below.





The organosilane hydrolyzates include a hydrolyzate of an organosilane alone and a hydrolyzed product of a mixture of an organo-silane and another silane such as $(\text{R}^2\text{O})_2\text{SiR}^1_2$ and $(\text{R}^2\text{O})_3\text{SiR}^1$ wherein R^1 and R^2 are as defined above.

Component (C) is colloidal silica. The colloidal silica need not be limited to a particular type. For example, colloidal silica species having a particles size of 10 to 40 μm and stabilized with sodium or aluminum ions are useful. They are commercially available, for example, as Snowtex 40 from Nissan Chemical K.K.

It is recommended to mix the colloidal silica with component (B) to form a uniform dispersion which is blended with the remaining components to form a composition. In mixing colloidal silica with component (B), more particularly (B-1), (B-2) or (B-3), 1 to 50 parts by weight of colloidal silica is preferably mixed with 0.01 to 10 parts by weight of component (B). More preferably, 0.1 to 20 parts by weight, especially 1 to 5 parts by weight of component (B) is used per 100 parts by weight of colloidal silica. Smaller amounts of component (B) would improve adhesion to a less extent whereas larger amounts of component (B) would reduce the flow of the coating composition.

This mixture or dispersion is prepared by gradually adding dropwise component (B) to a desired amount of colloidal silica while agitating at room temperature. Insoluble matter forms at the initial stage of dropwise addition, but continuing agitation turns the mixture into a wholly uniform, semi-transparent, flowing liquid dispersion.

The dispersion is blended with component (A), preferably in an amount of about 1 to 60 parts by weight, more preferably about 3 to 30 parts by weight per 100 parts by weight of the siloxane in component (A). Less than 1 part of the dispersion on this basis would sometimes result in Coatings with poor rubbery properties whereas more than 60 parts by weight of the dispersion would result in coatings which are low in elongation and thus susceptible to cracking.

It is to be noted that component (B) is effective not only in improving the adhesion of coatings to air bag fabrics, but also in enhancing the reinforcement of component (A) or organopolysiloxane by colloidal silica.

Component (D) is a curing catalyst which is used for curing the air bag coating composition. Examples of the curing catalyst include organic acid metal salts such as dibutyltin dilaurate, dioctyltin dilaurate, dibutyltin diacetate, tin octylat, tin laurat, iron octylate, lead octylate, tributyltitanate, amine compounds such as n-hexylamine and guanidine or hydrochloride salts thereof.

On use, the curing catalyst is desirably formed into an O/W emulsion in a conventional manner using water and an emulsifier.

Preferably, the curing catalyst is used in amounts of about 0.01 to 10 parts by weight, more preferably about 0.1 to 3 parts by weight per 100 parts by weight of the siloxane in component (A). Less than 0.01 part of the curing catalyst would fail to cure the coating composition to a satisfactory extent whereas more than

10 parts of the curing catalyst would provide no further effect to the curing reaction and rather allow the resulting elastomer to crack.

In preparing the air bag coating composition of the present invention from the above-mentioned components, it is essential to previously blend components (B) and (C) uniformly. The best blending order is to first prepare an aqueous silicone emulsion as component (A), mixing component (A) with a uniform pre-blend of components (B) and (C), and finally mixing component (D). This mixing is satisfactorily achieved by a conventional agitating machine. If component (B) (B-1, B-2 or B-3) is added to a mixture of components (A), (C) and (D), then a gel-like mass forms which cannot be uniformly dissolved by any agitation means.

The air bag coating composition is preferably adjusted to pH 3 to 12, more preferably pH 5 to 9. Outside this pH range, the coating composition gives rise to some handling problems. The pH range of 6 to 9 is most appropriate for the safety of the operator. For pH adjustment, a variety of pH adjusting agents may be used in accordance with a desired pH value. Sodium carbonate is the preferred pH adjusting agent.

If desired, the air bag coating composition of the invention may contain any of additives which are usually added to or blended in aqueous paints, for example, thickeners, debubbling agents, pigments, dyes, preservatives, and intofiers (e.g., aqueous ammonia).

The base fabrics of air bags to which coatings of the present composition are cured include fibers of nylon, Tetrön, Vinylön, polyester and polyurethane and woven fabrics thereof, with nylon and polyester being preferred. A plain weave is the useful weave.

The coating composition is applied to base fabrics by any desired coating technique, for example, calendaring, knife coating, brush coating, dipping, and spraying.

Thereafter, the coatings are cured, preferably by heat vulcanization at 110 to 150°C for several seconds to about 20 minutes. Then cured products having a varying crosslinking density covering silicone rubber, silicone resin and silicone gel are obtained depending on the particular components used. Room temperature curing is also possible. That is, simply by removing water therefrom, the composition can be cured at room temperature into an elastomer having acceptable rubbery properties. In either case, there is obtained a cured coating which firmly bonds to the base fabric and has a tack-free surface.

There has been described an air bag coating composition which is applied and cured to plain weave air bag fabrics, typically plain weave base fabrics comprised of polyimide and polyester fibers. Since no organic solvent is used, the composition is safe to the health of the operator during handling and coating operation. The composition cures into a coating which is characterized by an enhanced bond to the base fabric and a tack-free surface and has excellent rubbery properties. Consequently, the coating is resistant to cracking upon instantaneous inflation of the air bag.

35 EXAMPLE

Examples of the present invention are given below by way of illustration and not by way of limitation. Unless otherwise stated, all parts and percents are by weight.

40 Example 1

Air bag coating compositions were obtained by separately preparing Components (I), (II)-1 and (III) in accordance with the following procedures, and blending them in the proportion shown in Table 1 to form aqueous silicone emulsion compositions.

45 Component (I)

An aqueous silicone emulsion was prepared by emulsifying 500 parts of octamethyltetrasiloxane, 25 parts of methyltrimethoxysilane, 46.5 parts of water and 10 parts of dodecylbenzenesulfonic acid in a homomixer, passing twice the mixture through a homogenizer under a pressure of 3,000 psi to form a stable emulsion, charging a flask with the emulsion, and heating the flask to 70°C for 12 hours. The emulsion was cooled down to room temperature, allowed to stand for 24 hours, and then adjusted to pH 8.0 with sodium carbonate. The emulsion contained 47% of non-volatile matter. The organopolysiloxane which was separated from the emulsion using methanol has a viscosity of 7,200 centipoise as measured in 20% toluene solution at 25°C.

Component (II)-1

A uniform dispersion was prepared by adding dropwise 221 parts of 3-aminopropyltriethoxysilane to a mixture of 98 parts of maleic anhydride and 319 parts of ethanol while agitating the mixture. This reaction product, 30 parts, was gradually added dropwise to 1,000 parts of colloidal silica (Snowtex 40 commercially available from Nissan Chemical K.K., active ingredient 40%, Na_2O 0.6%, pH 9.3) at room temperature while agitating. There was obtained a semi-transparent uniform dispersion at pH 3.4.

Component (III)

A curing agent emulsion was prepared by emulsifying 30 parts of dibutyltin dilaurate, 1 part of polyoxyethylene nonyl phenyl ether and 69 parts of water in a conventional manner.

Example 2

An air bag coating composition was prepared as in Example 1 except that the following component (II)-2 was used instead of component (II)-1.

Component (II)-2

A semi-transparent uniform dispersion was prepared by gradually adding dropwise 30 parts of 3-epoxypropyltriethoxysilane to 100 parts of colloidal silica (Snowtex 40) at room temperature while agitating.

Example 3

An air bag coating composition was prepared as in Example 1 except that the following component (II)-3 was used instead of component (II)-1.

Component (II)-3

A semi-transparent uniform dispersion was prepared by gradually adding dropwise 30 parts of an isocyanate radical-containing silane represented by $(\text{C}_2\text{H}_5\text{O})_3\text{Si}(\text{CH}_2)_3\text{NCO}$ to 100 parts of colloidal silica (Snowtex 40) at room temperature while agitating.

Comparative Example

An air bag coating composition was prepared as in Example 1 except that component (II)-4 consisting solely of colloidal silica was used instead of component (II)-1.

Each of the coating compositions was applied to one surface of plain weave fabric of 420-denier nylon filaments (46 filaments/inch in warp and weft) to a dry coating thickness of about 100 μm . The coating was cured by allowing it to stand at a temperature of 20°C and a relative humidity of 60% for 48 hours. There was obtained a coated fabric.

Next, one part type silicone RTV rubber (KE-451T commercially available from Shin-Etsu Chemical Co., Ltd.) was applied to the cured coating on the fabric to a thickness of about 1 mm. Another similarly coated fabric was laid on the coated fabric such that the RTV rubber was sandwiched between the cured coatings. The RTV rubber was cured under conditions: 20 \pm 3°C, RH 45-65%, and 4 days. The assembly was cut to a strip of 2.5 cm wide and one fabric was pulled in a 180° direction by means of an autograph for measuring the bonding force, with which the adhesion of the coating to the fabric was evaluated.

Table 1

Component, parts	Example			Comparative Example
	1	2	3	
(I)	100	100	100	100
(II)-1	7.5	-	-	-
(II)-2	-	7.5	-	-
(II)-3	-	-	7.5	-
(II)-4	-	-	-	7.5
(III)	4.3	4.3	4.3	4.3
pH	8.0	8.0	8.0	8.0
Bonding force (kg/2.5 cm)	10.5 AR	11.0 AR	12.0 AR	0.2 IS
AR: adhesive (RTV rubber) rupture IS: separation at the interface between coating and nylon fabric				

Claims

1. An aqueous silicone emulsion composition for forming a coating on an air bag, comprising
 - (A) an aqueous silicone emulsion in which an organopolysiloxane having at least two hydroxyl radicals attached to silicon atoms in a molecule is emulsified in water,
 - (B) at least one member selected from the group consisting of a reaction product of an amino-functional silane or a hydrolyzate thereof with an acid anhydride, an epoxy-functional silane or a hydrolyzate thereof, and an organosilane having an isocyanate radical and a hydrolyzable radical in a molecule or a hydrolyzate thereof,
 - (C) colloidal silica, and
 - (D) a curing catalyst.
2. An air bag comprising a base fabric having applied thereon a cured coating of the composition of claim 1.



European Patent
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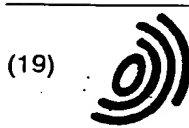
EUROPEAN SEARCH REPORT

Application Number

EP 92 11 6770

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-4 496 687 (FUMIO OKADA ET AL) * column 7, line 31 - line 36; claims; table 1 *	1	C09D183/04 D06M15/643 D06N3/12 B60R21/00
Y	----	2	
P,Y	WPIL, FILE SUPPLIER, DERWENT PUBLICATIONS LTD.;LONDON, GB.; AN=91-364514 & JP-A-3 243 442 (TORAY IND. INC.) 30-10-1991 * abstract *	2	
Y	WPIL, FILE SUPPLIER, DERWENT PUBLICATIONS LTD.; LONDON, GB.; AN=90-372957 & JP-A-2 270 654 (TAKATA KK) 05-11-1990 * abstract *	2	
A	EP-A-0 186 839 (TOSHIBA SILICONE CO LTD.) * the whole document *	1	
A	EP-A-0 131 870 (DOW CORNING CORPORATION) * the whole document *	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 DECEMBER 1992	Examiner BLAS V.
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X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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(54) Silicone coated fabric

(57) A coated textile fabric comprising at least two layers of siloxane elastomer, a first layer coated directly onto the fabric, having an elongation-at-break of at least

400% and a second layer having a tear-strength of at least 30kN/m. Also claimed is process of making these fabrics and airbags made from these fabrics.

EP 0 866 164 A1

Description

The present invention relates to a coated textile fabric, and in particular to a fabric coated with a silicone-based coating composition capable of maintaining a pressure barrier between two areas with a pressure differential. The invention also relates to a process of preparing such textile fabrics and to airbags made with coated fabrics.

Coating textile fabrics with silicone-based coating compositions has been known for a while. These compositions may impart a variety of benefits to the coated fabric. For example in EP 553,840, there is described a liquid silicone rubber coating composition for application to airbags in automobiles, which comprises a certain polydiorganosiloxane having alkenyl groups, an polyorganosiloxane resin, an inorganic filler, a certain polyorganohydrosiloxane, a platinum group metal catalyst and an epoxy group-containing organosilicon compound. In EP 646,672, there is described a fabric impregnated with a silicone composition comprising a certain linear polyorganosiloxane having aliphatic unsaturation, a certain polyorganohydrosiloxane, a catalyst promoting addition reaction, a hydrophobic silica, a flame retardant and optionally an adhesion promoting agent. The latter patent specification suggests the use of the composition for fabrics used in the construction of airbags. The benefit of using silicone-coated compositions over other, e.g. organic coating compositions, lies e.g. in the improved weatherability, ability to maintain flexibility and heat resistance of the silicone-based composition.

While fabrics coated with such compositions may be satisfactory for airbag applications, they do not satisfy requirements where pressurised fluids are to be retained in a fabric envelope for a relatively long period. This requirement exists for example in the application of such coatings to side curtain airbags for the automotive industry. These side curtain airbags are intended to inflate at the time of impact, as do conventional airbags. The side curtains unfold to form a cushioned curtain between passengers and some of the side of the car body, e.g., the windows. As the intention is not merely to cushion the blow on impact itself, as is the case for conventional driver and passenger airbags, but e.g. to protect passengers when a car is rolling, it is important that the side curtain air bag is sufficiently pressurised during such rolling process. Where conventional driver and passenger airbags only need to retain pressure for a fraction of a second, it is desirable that side curtain airbags maintain a suitable pressure for a few seconds. Similar applications exist where a pressurised fabric structure is desired to maintain a certain fluid pressure for a relatively extended period of time, e.g. in emergency chutes for aeroplanes, inflatable rafts etc.

We have found that a combination of certain silicone-based coating compositions can provide these benefits. In particular, we have found that applying multiple layers of silicone-based coating compositions, at least two layers having different characteristics, is very beneficial for such purpose.

Using more than one layer of a silicone based coating is known, and has been disclosed e.g. in US 4,587,159, where a transparent or translucent silicone coated glass fabric is described, comprising a first layer of polydiorganosiloxane in which the organic radicals are methyl and phenyl radicals in a ratio of from 0.25 to 3.7, impregnating and coating the yarns of the glass fabric but not filling in the interstices of the glass fabric; a second layer of silicone elastomer covering the first layer and filling in the interstices of the glass fabric; and a third layer of elastoplastic polyorganosiloxane resin to give a smooth dry surface. Coated glass fabrics according to that invention are stated as being transparent or translucent and useful for constructing structures such as air-supported and tension-supported roofs for structures such as greenhouses and solar heated buildings. Such materials are however not suitable for the coating of side curtain airbags.

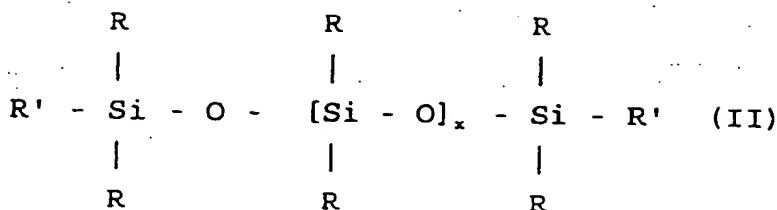
We have now found that by coating a textile fabric with a first layer of a silicone-based elastomer having a high elongation-at-break characteristic, and a second layer of a silicone-based elastomer having a high tear strength, a suitable fabric may be obtained for use as an automotive side curtain airbag.

According to the invention there is provided a coated textile fabric comprising a textile fabric, having at least two layers of an polyorganosiloxane-based elastomeric material, a first layer, coated onto the fabric, having an elongation-at-break of at least 400% and a second layer having a tear-strength of at least 30kN/m.

Suitable fabrics for use in the present invention are made from synthetic fibres or blends of natural and synthetic fibres, such as polyester, polyimides, polyethylene, polypropylene, polyester-cotton, glass fibre, most preferably polyamide fibres such as Nylon 6,6. They require to be flexible in order to be useful as inflatable bodies. Preferably they are sufficiently flexible to be able to be folded into relatively small volumes, but also sufficiently strong to withstand the deployment at high speed, e.g. under the influence of an explosive charge, and the impact of passengers or other influences when inflated.

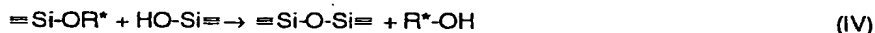
The organosiloxane elastomeric materials may be based on a number of organosiloxane systems which form elastomers upon curing. Many such organosiloxane systems are known and commercially available and many have been described in the literature. Suitable elastomer-forming organosiloxane systems comprise at least a siloxane polymer and an organosilicon cross-linker. Useful siloxane polymers have units of the general formula $R_aR'_bSiO_{4-a-b/2}$ (I), wherein R is a monovalent hydrocarbon group having up to 18 carbon atoms, R' is a monovalent hydrocarbon or hydrocarboxy group, a hydrogen atom or a hydroxyl group, a and b have a value of from 0 to 3, the sum of a+b being no more than 3. Preferably the siloxane polymers are polyorganosiloxanes of a generally linear nature having

the general structure (II)

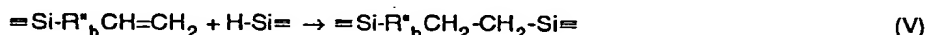


wherein R and R' have the same meaning as above, and wherein x is an integer, preferably having a value of from 10 to 1500. It is particularly preferred that R denotes an alkyl or aryl group having from 1 to 8 carbon atoms, e.g. methyl, ethyl, propyl, isobutyl, hexyl, phenyl or octyl. More preferably at least 50% of all R groups are methyl groups, most preferably substantially all R groups are methyl groups. R' is preferably selected from a hydroxyl group, an alkoxy group, an aliphatically unsaturated hydrocarbon group or a hydrogen atom. More preferably R' denotes either a hydroxyl group or alkoxy group having up to 3 carbon atoms suitable for condensation reactions, or an alkenyl group having up to 6 carbon atoms, more preferably vinyl, allyl or hexenyl, suitable for addition reactions.

Organosilicon cross-linkers are preferably selected from silanes, low molecular weight organosilicon resins and short chain organosiloxane polymers. The cross-linker compound has at least 3 silicon-bonded substituents which are capable of reacting with the silicon-bonded group R' of the polymer described above. Where the group R' is a hydroxyl or alkoxy group, it is preferred that the reactive substituents on the cross-linking organosilicon compound are either alkoxy groups or hydroxyl groups, allowing the condensation to take place between the two components according to the general reaction scheme (III) or (IV), wherein R* denotes an alkyl group



Where the group R' in the polymer is an alkenyl group, it is preferred that the reactive substituents R* on the cross-linking organosilicon compound are hydrogen atoms, allowing addition reaction between the cross-linking organosilicon compound and the polyorganosiloxane, according to the general reaction scheme (V), wherein R* is a divalent hydrocarbon group and b is 0 or an integer, preferably with a value of 1.



Suitable silanes which may serve as cross-linking organosilicon compounds include alkyltrialkoxo silane, e.g. methyltrimethoxy silane, ethyltrimethoxy silane, methyltriethoxy silane or methyltrihydrosilane. Suitable organosilicon resin compounds include organosilicon resins consisting mainly of tetrafunctional siloxane units of the formula $SiO_{4/2}$ and monofunctional units $R_v R^*_w Si_{1/2}$, wherein R is as defined above, R* denotes a silicon-bonded substituent which may react with R' as discussed above, v and w each have a value of from 0 to 3, the sum of $v+w$ being 3. Suitable short chain organosiloxane polymers include short chain polyorganosiloxanes having at least 3 silicon-bonded alkoxy, hydroxyl or hydrogen atoms per molecule, e.g. trimethylsiloxane end-blocked polymethylhydrosiloxane having up to 20 carbon atoms, tetramethylcyclotetrasiloxane and silanol end-blocked dimethylsiloxane-methylsilanol copolymers.

In addition to the siloxane polymers and the organosilicon cross-linking compounds, the elastomer-forming compositions preferably also comprise a suitable catalyst, selected according to the curing or cross-linking mechanism employed. For the preferred silicone based elastomer-forming compositions, which are based on curing by condensation, suitable condensation catalysts include tin or titanium based components, e.g. dialkyltin dicarboxylic acids and tetraalkyl titanates. For those silicone based elastomer-forming compositions which cure by addition reaction, it is preferred to use a Group VIII metal-based catalyst, e.g. platinum chloride, or compounds or complexes of platinum or rhodium.

Other additional components may be included in suitable elastomer-forming compositions, including fillers, chain extenders, dyes, adhesion promoters, colorants, pigments, viscosity modifiers, bath-life extenders, inhibitors and flexibilisers. Suitable fillers include silica, e.g. fumed silica, precipitated silica, gel-formation silica, aerosils, titania, ground

quartz, ground cured silicone rubber particles, calcium carbonate and glass microspheres. Preferably, the filler has been treated to make its surface hydrophobic where necessary, e.g. by treating with suitable silanes, short chain siloxanes, fatty acids or resinous silicone materials. Suitable materials and processes for rendering the surface of fillers hydrophobic have been described in the literature, and are known to the person skilled in the art. Adhesion promoters include epoxy-functional, organotitanates or amino-functional organosilicon compounds. Chain extenders tend to be organosiloxane materials which are predominantly linear in nature and which have a silicon-bonded group R³ at each end of the polymer, allowing it to react with the R¹ group of two siloxane polymers, this merely extending the length of the siloxane polymer.

It is preferred that the elastomer-forming compositions are based on organosilicon compounds which cure via the addition reaction. Particularly preferred is a composition which comprises a polyorganosiloxane having at least 2 silicon-bonded alkenyl groups per molecule, preferably vinyl, an organohydrogen cross-linking organosilicon compound, a Group VIII based catalyst and a filler. The ratio of these components in the elastomer-forming compositions are not critical, although it is preferred that the alkenyl-functional polyorganosiloxane polymer and the organosilicon cross-linker having silicon-bonded hydrogen atoms are present in a ratio which will ensure that at least one silicon-bonded hydrogen atom is present per alkenyl group, more preferably that the ratio would be from 1.1/1 to 5/1, most preferably from 2/1 to 4/1.

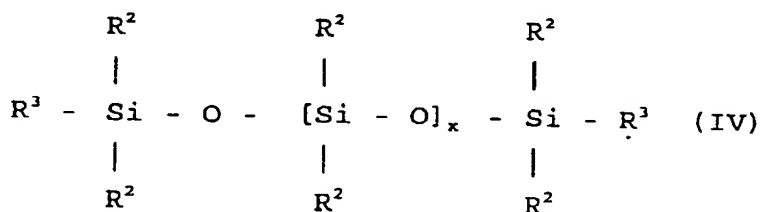
The first layer (A) is preferably obtained from an elastomer-forming composition which comprises

- (a) 100 parts by weight of a polyorganosiloxane material having on average two silicon-bonded alkenyl groups per molecule, preferably one linked to each of the terminal silicon atoms of the molecule;
- (b) an organosilicon compound having at least three silicon-bonded hydrogen atoms per molecule, in an amount which is sufficient to give a molar ratio of Si-H groups in (b) to alkenyl groups in (a) of from 1.1/1 to 4/1;
- (c) from 1 to 25 parts by weight of a chain extender, comprising a polyorganosiloxane having two silicon-bonded hydrogen atoms;
- (d) a group VIII based catalyst component in sufficient amounts to catalyse the addition reaction between (a) on the one hand and (b) and (c) on the other;
- (e) from 5 to 40 parts by weight of a hydrophobic filler.

The second layer (B) is preferably obtained from an elastomer-forming composition which comprises

- (a) 100 parts by weight of a polyorganosiloxane material having on average two silicon-bonded alkenyl groups per molecule, preferably one linked to each of the terminal silicon atoms of the molecule;
- (b) an organosilicon compound having at least three silicon-bonded hydrogen atoms per molecule, in an amount which is sufficient to give a molar ratio of Si-H groups in (b) to alkenyl groups in (a) of from 1.1/1 to 3/1;
- (c) 1 to 25 parts by weight of a polyorganosiloxane material having a silicon-bonded alkenyl group linked to each of the terminal silicon atoms of the molecule and in addition at least one alkenyl group linked to a non-terminal silicon atom in the polyorganosiloxane chain;
- (d) a group VIII based catalyst component in sufficient amounts to catalyse the addition reaction between (a) on the one hand and (b) and (c) on the other;
- (e) from 5 to 40 parts by weight of a hydrophobic filler.

More preferably polyorganosiloxane (A) (a) and (B) (a) is a polydiorganosiloxane having the general formula (IV)

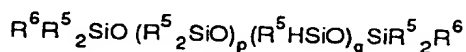


where R² denotes a monovalent hydrocarbon having up to 16 carbon atoms, preferably an alkyl or aryl group having up to 8 carbon atoms, more preferably a lower alkyl having up to 6 carbon atoms, most preferably methyl, R³ denotes a group having aliphatic unsaturation and having the general formula -R⁴_y-CH=CH₂, where R⁴ denotes a divalent hydrocarbon group having up to 6 carbon atoms, preferably an alkylene group having up to 4 carbon atoms, y has a value of 0 or 1, and x has a value of from 0 to 1500, preferably 50 to 1200, most preferably 70 to 800. It is most preferred

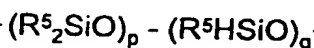
that polydiorganosiloxane (A)(a) and (B)(a) is an ω , ω -vinyldimethylsiloxy polydimethylsiloxane polymer having a viscosity of from 50 to 250,000 mPa.s at 25°C, more preferably 100 to 100,000 mPa.s, most preferably 250 to 55,000 mPa.s.

Organosilicon component (A) (b) and (B) (b) is preferably a short chain polyorganosiloxane having at least 3 silicon-bonded hydrogen atoms, preferably having a silicon-bonded hydrogen atom on the majority of silicon atoms in the molecule. Particularly preferred are organosilicon compounds which are substantially linear or cyclic compounds. However, small amounts of trifunctional or tetrafunctional siloxane units may also be present.

Preferred compounds for (A)(b) and (B)(b) are organosilicon compounds having the general formula



or



wherein R^5 denotes an alkyl or aryl group having up to 10 carbon atoms, R^6 is a group R^5 or a hydrogen atom, p has a value of from 0 to 20, q has a value of from 1 to 70, and there are at least 3 silicon-bonded hydrogen atoms present per molecule. It is not important if the silicon-bonded hydrogen atoms are on terminal silicon atoms for linear siloxane compounds or not. It is preferred that R^5 denotes a lower alkyl group having no more than 3 carbon atoms, most preferably a methyl group. R^6 preferably denotes an R^5 group. Preferably $p = 0$ and q has a value of from 6 to 70, more preferably 20 to 60, or where cyclic organosilicon materials are used, from 3 to 8. The cross-linking component may comprise a mixture of several organosilicon compounds as described.

The amount of cross-linking component (A) (b) or (B) (b) which is used in a composition is preferably sufficient to provide at least a ratio of the number of silicon-bonded hydrogen atoms over the number of alkenyl groups in the composition of about 1/1, i.e. in stoichiometric amounts. It is however, more preferred to have some stoichiometric excess of SiH groups present to ensure complete cross-linking of the composition. Preferred SiH/alkenyl ratios are from 1.1/1 to 5/1, more preferably 2/1 to 4/1.

Component (A) (d) and (B) (d) is a catalyst which is suitable for promoting the addition reaction of alkenyl groups with silicon-bonded hydrogen atoms. Suitable catalysts are accordingly those based on precious metals, particularly Group VIII metals, including ruthenium, rhodium, palladium, osmium, iridium and platinum. Preferably the catalyst is a well-known platinum compound or complex. Suitable platinum compounds and complexes include chloroplatinic acid, platinum acetylacetonate, complexes of platinum halides with unsaturated compounds such as ethylene, propylene, organovinylsiloxanes, and styrene, hexamethyldiplatinum, $PtCl_2$, $PtCl_3$, $PtCl_4$, and $Pt(CN)_3$. The preferred platinum catalyst is a form of chloroplatinic acid, either as the commonly available hexahydrate form or in its anhydrous form, as taught in US patent 2,823,218. Another particularly useful catalyst is the composition that is obtained when chloroplatinic acid is reacted with an aliphatically unsaturated organosilicon compound such as divinyltetramethyldisiloxane, as disclosed in US patent 3,419,593. It is preferred that catalyst (A) (d) or (B) (d) is employed in an amount giving from 2 to 100 ppm by weight of platinum metal based on the total weight of the total composition, more preferably 5 to 50 ppm.

Hydrophobic filler (A) (e) and (B) (e) is preferably a reinforcing filler. Examples of suitable fillers include silica, titania, ground quartz, calcium carbonate and aluminosilicates. Preferred are silica fillers, most preferably fumed silica fillers, as they have the best reinforcing properties. The average particle size of these fillers may be such that the diameter ranges from 0.1 to 20 μm , preferably from 0.2 to 5 μm , most preferably 0.4 to 2.5 μm .

The surface of the filler particles is rendered hydrophobic in order to make the filler more compatible with the compositions used in the present invention. Rendering the filler particles hydrophobic may be done either prior to or after dispersing the filler particles in the siloxane component. This can be effected by pretreatment of the filler particles with fatty acids, reactive silanes or reactive siloxanes. Examples of suitable hydrophobing agents include stearic acid, dimethyldichlorosilane, trimethylchlorosilane, hexamethyldisilazane, hydroxyl endblocked or methyl endblocked polydimethylsiloxanes, siloxane resins or mixtures of two or more of these. Other hydrophobing agents may also be used, but the above exemplified materials are the most effective. Fillers which have already been treated with such compounds are commercially available from a number of sources. Alternatively, the surface of the filler may be rendered hydrophobic in situ, i.e. after the filler has been dispersed in the siloxane material. This may be effected by adding to the polysiloxane component prior to, during or after the dispersion of the filler, an appropriate amount of a hydrophobing agent of the kind described above as reactive silanes or siloxanes, and heating the mixture sufficiently to cause reaction, e.g. a temperature of at least 40°C. The quantity of hydrophobing agent to be employed will depend for example on

the nature of the agent and of the filler, and will be evident or ascertainable by those skilled in the art. Sufficient hydrophobic agent should be employed to endow the filler with at least a discernible degree of hydrophobicity.

Component (A)(c) is a polyorganosiloxane preferably having diorganosiloxane units and hydrodiorgano siloxane end-blocking units. Because of the nature of these polymers, they serve as chain-extenders, adding to an alkenyl group of (A) (a) upon curing. Preferably these polymers have a viscosity which is in the range of from 5 to 100 mPa.s at 25°C.

Component (B)(c) is a polyorganosiloxane material having a silicon-bonded alkenyl group linked to each of the terminal silicon atoms of the molecule and in addition at least one alkenyl group linked to a non-terminal silicon atom in the polyorganosiloxane chain. Such materials are similar to the siloxane materials (B) (a) described above. The main difference that the preferred materials have in addition to an alkenyl group linked to siloxane units which are terminal to the molecule, that at least one more alkenyl group is present linked to a silicon atom in the siloxane chain. Preferably the polyorganosiloxane is a copolymer of dialkylsiloxane units and alkenyldialkylsiloxane units, which are end-blocked by alkenyldialkylsiloxane units. More preferably the copolymer is a vinyltrimethyl siloxane end-blocked dimethylsiloxane vinylmethylsiloxane copolymer having about 1 to 5 mole % vinyl groups per molecule. Most preferred copolymers (B) (c) have a viscosity of from 150 to 600 mPa.s at 25°C.

Compositions (A) and (B) may be made by merely mixing the ingredients in the desired ratios. However, for reasons of storage stability and bath life before or during application of the compositions to the textile fabric, it is preferred to store each of the compositions in two parts, by separating the catalyst (d) from the Si-H functional materials [i.e. (A) (b), (A) (c) and (B) (c)]. The other components of the compositions are often distributed over both parts in proportions which will allow easy mixing of the two parts immediately prior to application. Such easy mixing ratios may be e.g. 1/10 or 1/1 ratios.

Composition (A) has to have a very good elongation-at-break characteristic, when tested as a self-supporting elastomeric material. This is a well-known property of elastomeric materials and a person skilled in the art will be able to determine this characteristic with known techniques, e.g. DIN standard 53409. It is preferred that the elongation at break is from 600 to 1000%. Preferred compositions have from 50 to 90% by weight of component (A) (a), from 0.5 to 10% by weight of component (A) (b), from 0.5 to 10% by weight of component (A) (c), from 5 to 40% by weight of component (A) (e) and sufficient of component (A) (d) to ensure the addition reaction of (A)(a) to (A)(b) and (A)(c) takes place under normal curing conditions.

Composition (B) has to have a very good tear strength characteristic, when tested as a self-supporting elastomeric material. This is a well-known property of elastomeric materials and a person skilled in the art will be able to determine this characteristic with known techniques, e.g. ASTM D624 B. It is preferred that the tear strength is from 35 to 60 kN/m. Preferred compositions have from 50 to 90% by weight of component (B) (a), from 0.5 to 10% by weight of component (B) (b), from 0.5 to 10% by weight of component (B) (c), from 5 to 40% by weight of component (B) (e) and sufficient of component (B) (d) to ensure the addition reaction of (B) (a) and (B)(c) to (B) (b) takes place under normal curing conditions.

The compositions may be applied according to known techniques to the textile fabric substrates. These include spraying, coating by knife-over-roller, coating by knife-over-air, padding and screen-printing. It is preferred that each of the compositions are applied to a coat-weight prior to curing of at least 20 g/m². Preferably the coating thickness of the first layer is from 25 to 70 g/m², more preferably 30 to 50 g/m². The second layer is preferably applied at a thickness of from 35 to 150 g/m², more preferably 50 to 100 g/m². In order to make the compositions easily applicable to the textile fabric, it is preferred that the viscosity of composition (A) is from 50,000 to 200,000 mPa.s, and that of composition (B) from 80,000 to 300,000 mPa.s.

Application to the textile fabric of Composition (A) may take place under normal conditions, preferably of course the conditions are sufficiently clean to avoid entrapment of foreign bodies during the application. The textile fabric is preferably scoured prior to application, in order to ensure good adhesion of the composition. Composition (B) may be applied on top of Composition (A) prior to or following curing of Composition (A). Preferably composition (A) is cured prior to application of composition (B), which is cured subsequently. It is however possible that between compositions (A) and (B) there is applied one or more additional organosilicon-based elastomeric compositions, preferably of elongation-at-break and tear-strength characteristics in between those of compositions (A) and (B). Most preferably, however, Composition (B) is applied directly onto Composition (A). It is also possible to apply onto Composition (B) a further coating, e.g. of a material providing low friction, or, even more preferably, an additional textile fabric, whether woven or non-woven, to improve the strength and/or the feel of the fabric.

Curing conditions for compositions (A) and (B) are preferably at elevated temperatures over a period which will vary depending on the actual temperature used. Suitable curing conditions for the preferred compositions are 120 to 200°C for a period of up to 5 minutes.

According to the invention there is also claimed a process for coating textile fabric with a first layer of an polyorganosiloxane-based elastomeric material having a elongation-at-break of at least 400% and a second layer, having a tear-strength of at least 30 kN/m, and causing the first and second layer to cure to form an elastomeric coating on the fabric.

Preferably the first layer is applied and caused to be cured prior to the application of the second layer to the first, although it is possible to apply the second layer onto the first and causing both layers to cure at the same time.

The advantage of the combination of the two layers of coating on the surface of a textile fabric is that the fabric becomes much more able to form a barrier between areas of differing pressure. Particularly useful applications for textile fabrics coated according to the present invention are those applications where the fabric is formed into an envelope and pressure is applied inside the envelope, e.g. by introducing gas into the envelope and thus inflating it. Particularly useful applications include automotive airbags, emergency shoots on aeroplanes, hot air balloons. The most valuable use of fabrics according to the invention is in the production of side curtain airbags for automobiles, where the internal pressure of the envelope needs to be maintained for a relatively long period of time, e.g. from 1 to 5 seconds.

The following examples, where parts and percentages are given in weight, unless otherwise stated and where viscosity is dynamic viscosity at 25°C, illustrate the invention.

Examples

A first composition (I) was prepared by mixing together 70 parts of an α , ω -vinyl dimethylsiloxane end-blocked polydimethylsiloxane having a viscosity of about 2Pa.s, 30 parts of a fumed silica which had its surface made hydrophobic and 0.002 parts by weight of a platinum based catalyst. Composition (I) had a viscosity of 100Pa.s.

A second composition (II) was prepared, containing 64 parts by weight of an α , ω -vinyl dimethylsiloxane end-blocked polydimethylsiloxane having a viscosity of 2Pa.s, 26 parts by weight of a fumed silica which had its surface made hydrophobic, 4 parts by weight of an methylhydrosiloxane dimethylsiloxane copolymer having trimethylsiloxane end-blocking units, at least 3 silicon-bonded hydrogen atoms per molecule and a viscosity of about 5mPa.s and 5 parts by weight of a dimethylsiloxane having dimethylhydrosiloxane end-blocking units and a viscosity of about 10 mPa.s. Composition (II) had a viscosity of 100Pa.s.

A third composition (III) was prepared containing 64 parts of an α , ω -vinyl dimethylsiloxane end-blocked polydimethylsiloxane having a viscosity of about 55Pa.s, 25 parts of a fumed silica which had its surface made hydrophobic, 0.002 parts by weight of a platinum based catalyst, and 9 parts of a dimethylsiloxane methylvinylsiloxane copolymer having vinyl dimethylsiloxane end-blocking units and a viscosity of about 350mPa.s. Composition (III) had a viscosity of 175Pa.s.

A fourth composition (IV) was prepared by mixing together 61 parts of an α , ω -vinyl dimethylsiloxane end-blocked polydimethylsiloxane having a viscosity of about 55Pa.s, 25 parts of a fumed silica which had its surface made hydrophobic, 3 parts by weight of an methylhydrosiloxane dimethylsiloxane copolymer having trimethylsiloxane end-blocking units, at least 3 silicon-bonded hydrogen atoms per molecule and a viscosity of about 5mPa.s and 9 parts of a dimethylsiloxane methylvinylsiloxane copolymer having vinyl dimethylsiloxane end-blocking units and a viscosity of about 350mPa.s. Composition (IV) had a viscosity of 175Pa.s.

A comparative elastomer-forming composition (C) was prepared by mixing 5 parts of a first composition comprising 64 parts of a 70/30 mixture of a dimethylvinylsiloxyl-terminated polydimethylsiloxane and hydrophobic silica, 26 parts of ground quartz, 4 parts of calcium carbonate and a catalytic amount of a platinum based catalyst and 1 part of a second composition comprising 50 parts of a 70/30 mixture of a dimethylvinylsiloxyl-terminated polydimethylsiloxane and hydrophobic silica, 46 parts of a dimethylsiloxane methylhydrogen siloxane copolymer having silicon-bonded hydrogen atoms on about 50% of the silicon atoms.

EXAMPLE 1

A double layered polyamide fabric of 470 Dtex was made into side curtain master batch (containing envelopes of the fabric woven into that fabric structure) coated on both sides of the fabric by a knife over roller technique with a 50/50 elastomer-forming mixture of compositions (I) and (II) to a coat weight of 50-60g/m², followed by heating the coated fabric for 2 minutes at 150-170°C. After allowing the coated fabric to cool to room temperature, a second coating was applied on top of the first coating using a 50/50 elastomer-forming mixture of Compositions (III) and (IV), to a coat weight of 100g/m², after which the coated fabric was reheated as before. This resulted in a coated fabric having two layers of a silicone-based coat, the first layer having an elongation-at-break (when tested as a self-supporting elastomeric material) of more than 600%, and a second layer having a tear strength (when tested as a self-supporting elastomeric material) of 45-50kN/m.

The fabric was then cut to give closed envelope side curtain airbags of 2 metre by 0.5 metre dimensions, having an entry point, through which the envelope was inflated with air under explosive conditions to a pressure of 250 kPa. The pressure in the sealed envelope was then measured after 3 seconds and after 5 seconds. In addition the leakage rate was derived from the pressure change vs. time, and is measured in kPa/s/bar. Better performance is indicated by lower leakage rates and higher residual pressures. Details of the test results are given below in Table I.

COMPARATIVE EXAMPLES C1-C5

All examples were carried out according to the process of Example 1, except that in some cases only one coat of silicone material was coated onto the fabric. In Comparative Example C1, Composition C was coated at a coat weight of 70g/m²; in Comparative Example C2, a mixture of Compositions (III) and (IV) was coated at a coat weight of 50-70 g/m²; in Comparative Example C3 two layers of the coat applied in Comparative Example C2 were applied; in Comparative Example C4, a base coat according to Example C1 was applied and a top layer according to Comparative Example C2; in Comparative Example C5, a base coat according to Example 1 was applied, and a top coat according to Comparative Example C1. Test results are also given in Table I below.

TABLE I

Example	Leakage rate kPa/s/bar	Residual pressure after 3 seconds	Residual pressure after 5 seconds
1	8	180 kPa	70 kPa
C1	600	N/D	N/D
C2	150	N/D	N/D
C3	133	N/D	N/D
C4	90	20 kPa	N/D
C5	N/A	N/D	N/D

where N/D means that the value was so low it was not detectable, and N/A means the calculation was not done.

EXAMPLES 2-5

Polyamide fabric was coated with compositions as in Example 1, except for the fact that the envelopes were only the A4 size. Example 2 used the same composition and coat weights as Example 1, in Example 3 the second layer was only applied at a coat weight of 50g/m², in Example 4 the first layer was coated at 100g/m² and the second layer at 50g/m² and in Example 5 for both layers were coated at 100g/m². The envelopes were subsequently tested in the same way as those of Example 1, except that no leakage rates were calculated. Test results are given in Table II below, but because of the different size of the envelopes, the results cannot be compared with those given in Table I.

COMPARATIVE EXAMPLES 6-7

Polyamide fabric was coated as for Examples 2 to 4, with the difference that in Comparative Example C6, a coating according to Comparative Example C1 was applied at a coat weight of 100g/m² and in Comparative Example C7,

Composition C was applied at a coat weight of 150g/m². The envelopes were tested in the same way as Example 1, but no leakage ratios were calculated. Results are given in Table II.

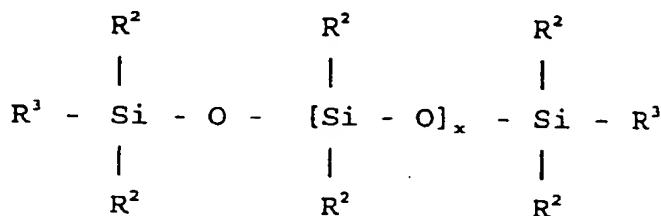
TABLE II

Example	Residual pressure after 3 seconds	Residual pressure after 5 seconds
2	100 kPa	70 kPa
3	30 kPa	10 kPa
4	30 kPa	10 kPa
5	120 kPa	100 kPa
C6	N/D	N/D
C7	N/D	N/D

where N/D denotes the pressure was so low that it could not be detected.

Claims

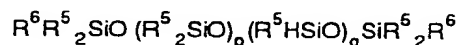
1. A coated textile fabric comprising a textile fabric, having at least two layers of an polyorganosiloxane-based elastomeric material, characterised in that the first layer is coated onto the fabric and has an elongation-at-break of at least 400% and in that the second layer has a tear-strength of at least 30kN/m.
2. A coated textile fabric according to Claim 1, further characterised in that the textile fabric is made from polyamide fibres.
3. A coated textile fabric according to Claim 1 or 2, further characterised in that the first layer has an elongation-at-break from 600 to 1000% and in that the second layer has a tear strength from 35 to 60kN/m.
4. A process for coating a textile fabric which comprises applying a first layer of an polyorganosiloxane-based elastomer-forming composition to the textile fabric, applying a second layer of an polyorganosiloxane-based elastomer-forming composition, and causing the first and second layer to cure to form an elastomeric coating on the fabric, characterised in that the first layer forms, upon curing, an elastomeric material having an elongation-at-break of at least 400%, and in that the second layer forms, upon curing, an elastomeric material having a tear-strength of at least 30kN/m.
5. A process according to Claim 4, further characterised in that the elastomer-forming composition (A) used to form the first layer comprises
 - (a) 100 parts by weight of a polyorganosiloxane material having on average two silicon-bonded alkenyl groups per molecule, preferably one linked to each of the terminal silicon atoms of the molecule;
 - (b) an organosilicon compound having at least three silicon-bonded hydrogen atoms per molecule, in an amount which is sufficient to give a molar ratio of Si-H groups in (b) to alkenyl groups in (a) of from 1.1/1 to 5/1;
 - (c) from 1 to 25 parts by weight of a chain extender, comprising an polyorganosiloxane having two silicon-bonded hydrogen atoms;
 - (d) a group VIII based catalyst component in sufficient amounts to catalyse the addition reaction between (a) on the one hand and (b) and (c) on the other;
 - (e) from 5 to 40 parts by weight of a hydrophobic filler and in that the elastomer-forming composition (B) used to form the second layer comprises
 - (a) 100 parts by weight of a polyorganosiloxane material having on average two silicon-bonded alkenyl groups per molecule, preferably one linked to each of the terminal silicon atoms of the molecule;
 - (b) an organosilicon compound having at least three silicon-bonded hydrogen atoms per molecule, in an amount which is sufficient to give a molar ratio of Si-H groups in (b) to alkenyl groups in (a) of from 1.1/1 to 5/1;
 - (c) 1 to 25 parts by weight of a polyorganosiloxane material having a silicon-bonded alkenyl groups linked to each of the terminal silicon atoms of the molecule and in addition at least one alkenyl group linked to a non-terminal silicon atom in the polyorganosiloxane chain;
 - (d) a group VIII based catalyst component in sufficient amounts to catalyse the addition reaction between (a) on the one hand and (b) and (c) on the other and
 - (e) from 5 to 40 parts by weight of a hydrophobic filler.
6. A process according to Claim 5, further characterised in that polyorganosiloxane (A) (a) and/or (B) (a) is a polydiorganosiloxane having the general formula



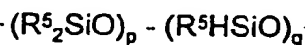
where R^2 denotes a monovalent hydrocarbon having up to 16 carbon atoms, R^3 denotes a group having aliphatic

unsaturation and having the general formula $-R^4-CH=CH_2$, where R^4 denotes a divalent hydrocarbon group having up to 6 carbon atoms, y has a value of 0 or 1, and x has a value of from 0 to 1500.

7. A process according to Claim 5 or 6, further characterised in that organosilicon compounds (A) (b) and/or (B) (b) have the general formula



or



wherein R^5 denotes an alkyl or aryl group having up to 10 carbon atoms, R^6 is a group R^5 or a hydrogen atom, p has a value of from 0 to 20, q has a value of from 1 to 70, and there are at least 3 silicon-bonded hydrogen atoms present per molecule.

8. A process according to any one of Claims 5 to 7, further characterised in that hydrophobic filler (A) (e) and/or (B) (e) comprises a fumed silica filler, the surface of which is rendered hydrophobic by treatment of the filler particles with fatty acids, reactive silanes or reactive siloxanes.
9. A process according to any one of Claims 5 to 8, further characterised in that Component (A) (c) is a polyorganosiloxane having diorganosiloxane units and hydrodiorgano siloxane end-blocking units.
10. A process according to any one of Claims 4 to 9, further characterised in that each polyorganosiloxane-based elastomer-forming composition is applied to the textile fabric by a method selected from spraying, coating by knife-over-roller, coating by knife-over-air, padding or screen-printing to a coating thickness for the first layer from 25 to 70g/m², and for the second layer from 35 to 150g/m².
11. An envelope, capable of holding a gas under pressure for a period of time, characterised in that it is made from textile fabric as claimed in any one of Claims 1 to 3.
12. An automotive airbag characterised in that it is made from coated textile fabric according to any one of Claims 1 to 3.

EP 0 866 164 A1



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EUROPEAN SEARCH REPORT

Application Number
EP 98 30 1891

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
D, A	US 5 401 566 A (MAGEE WALTER L ET AL) 28 March 1995 * the whole document *	1	D06M15/643 D06N3/12 B60R21/16
D, A	EP 0 553 840 B (DOW CORNING TORAY SILICONE) 27 March 1996 * the whole document *	1	
D, A	US 4 587 159 A (GUTER BETH I ET AL) 6 May 1986 * the whole document *		
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			D06M D06N B60R
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 19 June 1998	Examiner Heywood, C
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